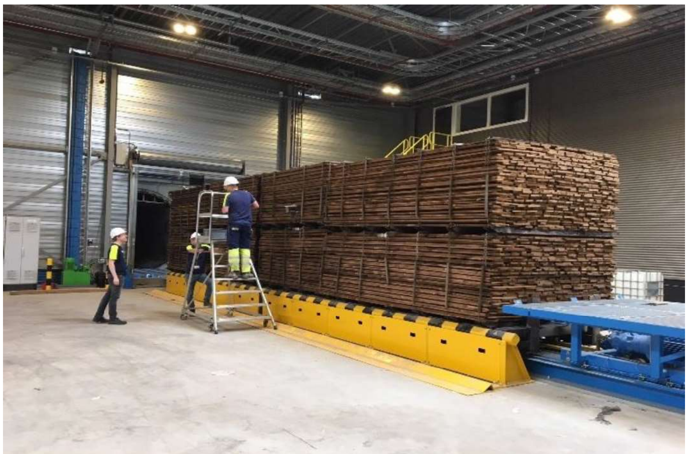
9th European Conference on Wood Modification
ECWM9

September 17 and 18, 2018, Arnhem, The Netherlands

BOOK OF ABSTRACTS



SHR

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The Netherlands • Arnhem • September 17-18, 2018

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9th European Conference on Wood Modification

Bugers' Zoo

Arnhem, The Netherlands

17-18 September 2018

In association with:

COST FP1407 ModWoodLife

Edited by:

Jos Creemers, Thomas Houben, Bôke Tjeerdsma, Holger Militz

and Brigitte Junge

Secretariat:
SHR B.V.
Nieuwe Kanaal 9b
6709 PA Wageningen
www.ecwm9.shr.nl

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Nieuwe Kanaal 9b, 6709 PA Wageningen, The Netherlands

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Preface

SHR was one of the first research institutes in Europe, who already in the 1990´s did substantial research work to develop wood modification processes. It appeared, that this research area was very complex, and that for a successful application of potential processes different expertise's was needed. A good network between research partners and industry was needed and the "European Network on Wood Modification" was created. 15 years ago, in 2003, the first European Conference on Wood Modification "ECWM" was held to present the outcomes of this EU financed network. Since than, ECWM´s were held each 2-3 years at different places around Europe, and now we can celebrate the 9th ECWM in the Netherlands, organized by SHR where it all began.

As already before, ECWM 9 is linked up to the European COST organisation. Thanks to the COST Action FP 1407 ModWoodLife to join and strengthen our network!

The participation of researchers of all around the world make it obvious that the name "European conference" is much too small…so: a warm welcome to researchers from industry and academia from Europe and abroad! This success has led, once again, to a large number of abstracts submitted to the organizers. In general, these abstracts were of a high quality and the members of the Scientific Committee had a hard time to select 44 full presentations and 50 poster presentations out of the many applications. We hope we have found the right balance between scientific and applied presentations to reach the key goal of ECWM: to attract researchers from academia and industry to join their expertises in this very exciting research area "wood modification".

The local conference organizers from SHR have done a great job this past year to make us feel welcome in The Netherlands and to let the conference be a success. Thank you very much to Bôke and team!

Prof. Dr. Holger Militz
Chairman of Scientific Committee
Georg-August-University Göttingen, Germany

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Wood modification in practice

The European Conference on Wood Modification takes place on the 17th and 18th of September 2018 in Arnhem, The Netherlands and is organised by SHR. At this conference researchers and people from industry from all over the world will come together to share their knowledge and experiences with the latest developments on wood modification methods, applications and products. The conference was given the subtitle “Wood modification comes home”, which refers to the role The Netherlands and SHR have played – and still play – in the development and industrial application of modified wood.

Techniques and methods designed for improving wood properties are almost as old as mankind itself. However the scientific and industrial rise of wood modification became significant under the influence of a number of social and economic developments in the eighties and nineties of the previous century. A strong need was felt to find alternatives for the use of tropical hardwoods and preservative treated wood, which were both under pressure for a variety of reasons. The discussions regarding a clean environment, sustainable forest management, wood use and the increasing wood demands from emerging markets in Asia also had a big impact. Wood modification was recognized to have the ability to offer a more, better and sustainable way of making use of wood as a durable material in a broad range of applications. Besides that, it was found to be a supreme method for upgrading the properties of lesser used timber species and to provide technical solutions to overcome some of the natural deficiencies of wood as water uptake, decay and dimensional changes.

Over the last decades an enormous amount of scientific work has been performed and published. We have seen many innovative modification ideas, methods and techniques passing by during the previous eight ECWM’s. To make a real impact, ideas need to be developed further and put into practice. We are proud that in The Netherlands we have created a setting with a high level of knowledge, innovative thinking combined with entrepreneurship, which lead to a variety of flourishing companies involved in industrial production of modified wood. Not only producing companies, but also the wood processing industry has adopted modified wood as a highly appreciated durable material. We can declare that modified wood has become a lasting factor in the wood processing industry.

For these reasons SHR and we as the organising team, are excited to welcome you all here in The Netherlands for the 9th European Conference on Wood Modification. We hope you will enjoy your stay here in Arnhem and become inspired by all attendees, presenters and new insights this conference has to offer.

Welcome!

The organising team

COST 1407 - Foreword

It is our pleasure that COST Action FP1407 "Understanding wood modification through an integrated scientific and environmental impact approach" (ModWoodLife) in part of 9th European Conference of Wood Modification. The conference brings together researchers from across Europe and beyond that jointly are addressing the mounting pressure on renewable resources (as a material source, for recreational, ecological, and other uses). By maximising the efficiency of materials derived from them, the wood modification community plays an important role. The efficiency can only be achieved if new methods to improve the functionality, durability, properties, and environmental impacts will be developed. Wood modification addresses these requirements directly, allowing wood to be used in more applications, including increased use of under-utilised species. Wood modification also addresses undesirable characteristics of wood such as fungal resistance, UV-stability, and moisture sensitivity. The COST Action FP1407 has been successful in addressing these needs in the past 3 years. We are in the last year of the Action and therefore it is even more important for us to be at ECWM9. Only sustainable collaboration and joint efforts will deliver the impacts. That objective of the Action FP1407, to characterise the relationship between wood modification processing, product properties, and the associated environmental impacts in order to maximise sustainability and minimize environmental impacts, has great value for the forest sector, for researchers, and society at large.

Wishing you a successful and memorable conference full of fruitful discussions.

Andreja Kutnar
Chair, COST FP1407

Denis Jones
Vice-Chair, COST FP1407

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Cutting forces when machining thermally modified poplar – preliminary results

Giacomo Goli[1], Rémi Curti[2], Bertrand Marcon[2], Antonio Scippa[3], Marco Fioravanti[1], Gianni Campatelli[3], Louis Denaud[2]

[1]GESAAF - University of Florence, Via S. Bonaventura 13, IT-50145, Florence [email: giacomo.goli@unifi.it – marco.fioravanti@unifi.it]
[2]LaBoMaP – Arts et Métiers Paristech, Rue porte de Paris, FR-71250 Cluny [email: remi.curti@ensam.eu, bertrand.marcon@ensam.eu, louis.denaud@ensam.eu]
[3] DIEF - University of Florence, Via Santa Marta 3, IT-50139, Florence [email: antonio.scippa@unifi.it – gianni.campatelli@unifi.it]

Keywords: cutting forces, grain orientation, poplar wood, thermal modification

ABSTRACT

This work explores the possibility, with a simple and innovative procedure, to assess the machining properties of thermally modified wood for a whole set of grain orientations and compare the results with unmodified wood. An experimental test set up was designed, few exploratory tests performed and a data analysis procedure developed. This method has shown to work fine to describe and compare the cutting forces of unmodified and thermally modified wood at different grains orientations. With a simple test a whole set of grain orientations can be acquired and with few tests performed at different depths of cut it is possible to evaluate the specific cutting forces. The forces when machining unmodified and thermally modified wood have shown to be very similar when machining along the grain. However, the cutting forces when machining thermally modified wood with or against the grain have shown to be lower than for untreated wood. The data analysis method, actually based on filtering the signals that are strongly affected by the system dynamical excitation, should be improved in order to calculate the real cutting forces acting.

INTRODUCTION

The use of thermally modified wood is getting more and more frequent in different uses such as: internal furniture for its dark colour, in use in wet conditions, external use where durability and hygroscopic stability are needed. It is also getting easier and easier to find this product on the market. Even if thermally modified wood is not a new product, the efforts of researchers until now have been focused mainly on treatment processes, chemical analysis, durability, dimensional stability, and mechanical performances. The machining of modified wood is something not very explored yet. Some information about handling, machining and gluing of this material can be found on (Finnish ThermoWood Association 2003). The quality after machining has also been assessed by different authors such as (de Moura *et al.* 2011; Budakçı *et al.* 2013; de Moura Palermo *et al.* 2014; Tu *et al.* 2014; Palermo Pires De Moura *et al.* 2015; Sandak *et al.* 2017). The cutting forces as well as the specific cutting coefficients are not investigated yet. In this article, the general approach described in (Goli and Sandak 2016) was used for the machining of unmodified and thermally modified poplar wood disks. The same disk (one for thermally modified wood and one for unmodified wood) was machined with different depths of cut (0.3, 0.7, 1.1, 1.5 mm) and the forces measured on two horizontal orthogonal directions (X, Y) in order to assess the cutting forces when machining with different depths of cut and grain orientations. This work is not meant to give extensive information on cutting forces and to precisely assess the specific cutting coefficients; but the aim is to explore the possibility to assess the machining properties of thermally modified wood at a whole set of grain orientation, compared to unmodified wood using an innovative and rapid procedure.

EXPERIMENTAL

Two boards of unmodified and thermally modified poplar wood (*Populus* sp.) were machined into a disk shape. Afterward, the disk was stiffly screwed on a Kistler 9255 type tri-axial piezoelectric dynamometric platform for the measurement of the cutting forces. The platform was driven by a Kistler type 5019 charge amplifier set with 100 $N.V^{-1}$ and "Long" time constant mode. The tests on the disks were done with a low-pass filter with a cut-off frequency of 10 kHz in order to avoid aliasing. The disk was machined using a SCM Record 1 3-axis CNC centre. The machining was done by a single straight blade balanced tool in order to get an invariant chip thickness.

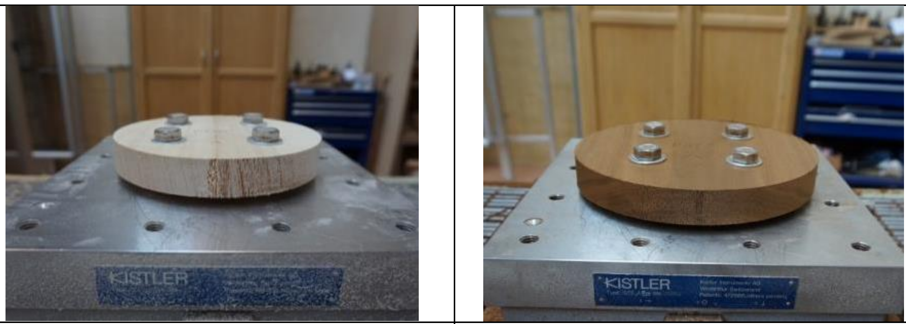

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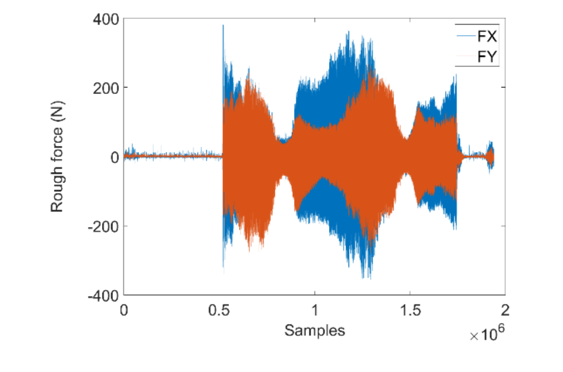
Figure 1: Experimental set up of the wood disks screwed on the dynamometric platform. a) untreated poplar and b)thermally modified poplar.

The diameter of the tool was 80 mm and the blade was a tungsten carbide freshly sharpened insert with a rake angle of 25° and a blade angle of 55°. The spindle was set to rotate at 3000 rpm both for measurement and preparatory cut. For every depth of cut the surface was prepared before the measurement by machining 0.2 mm of depth of cut in 5 successive steps with a feeding speed of 1 $m.min^{-1}$. The measurement of the cutting forces was done after surface preparation, machining with up-milling technique and with a feeding speed of 3 $m.min^{-1}$. The analogue outputs of the charge amplifiers were acquired synchronously with a sampling frequency of 50 kHz by a 16 bits National Instrument acquisition board model NI-9215 installed on a USB chassis model cDAQ-9174. The different channels were acquired by DASYLab® software and analysed with MATLAB®. Wood was machined after a stabilizing period in internal environment with a moisture content of 7.8% for untreated one and 6.4% for thermally modified one. The density at standard environmental conditions (20 °C @ 65% relative humidity) was determined to be 330 $kg.m^{-3}$ and 340 $kg.m^{-3}$for for untreated and thermally modified wood respectively. Thermally modified poplar was treated at 215 °C using the ThermoWood® process. The rough signals obtained machining a disk are shown in Figure 2a for X- and Y-axis. As can be seen the noise, depending on the dynamic excitation of the system, is very high and the vibration of the machine does not allow to separate positive and negative forces. The cut in milling with one blade is highly discontinuous explaining why the whole system (wood disk + dynamometer + machine environment) is strongly solicited dynamically to vibrate at its natural frequency (about 1.5 kHz). In order to verify that the rough force could include relevant information of the acting process, the signals were low-pass filtered with a cutting frequency of 200 Hz. The result of the filtering is shown in Figure 2b. As it can be observed, a large part of the free vibration is removed. The values of forces obtained with this procedure were then plotted as absolute values versus the angular position for the X-axis (Figure 2c) and for the Y-axis (Figure 2d) and the envelope extracted through a Matlab® code. Both graphs present two symmetric parts corresponding to first and second half of the disk. The X- and Y-axis envelope values were then used to calculate the resulting force as sum of vectors, as reported in Figure 2e. Because the disk is made of two equal halves (axially symmetric regarding the grain orientation), the resulting force was computed as the average of these two halves (Figure 2f).



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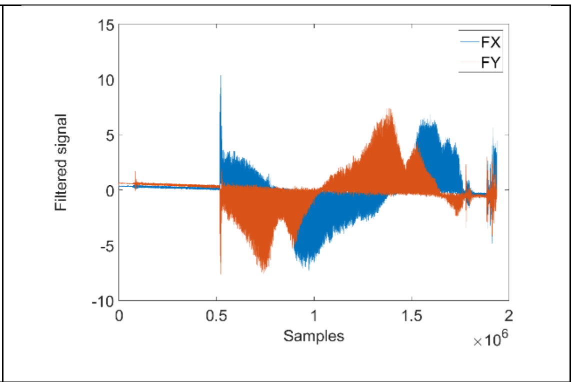

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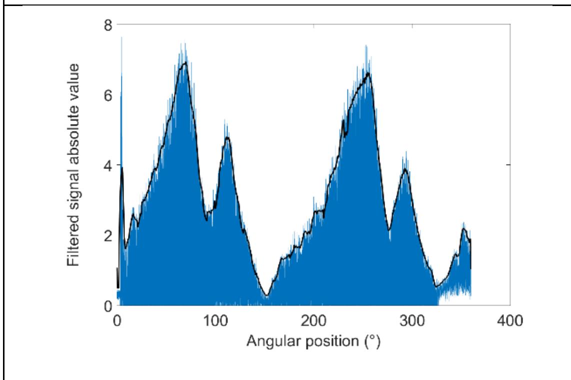

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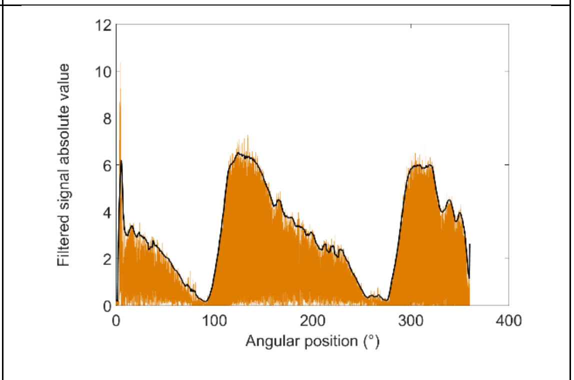

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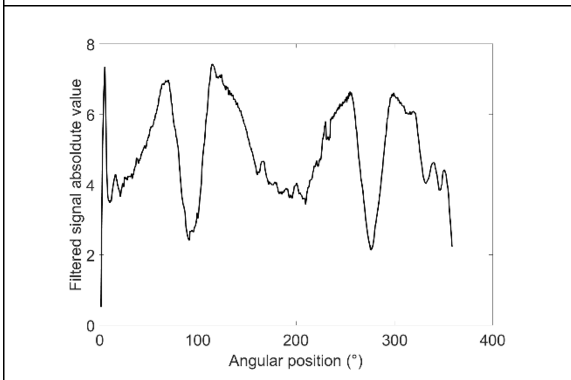

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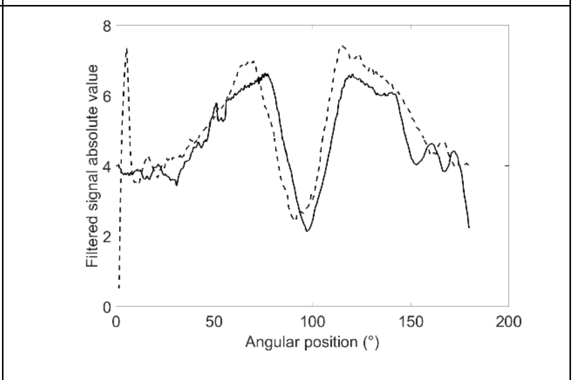

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***Figure 2:** These graphs are obtained by processing the test performed on thermally modified poplar wood machining with a depth of cut of 1.1 mm. a) Rough forces vs number of samples, b) 200 Hz low-pass filtered cutting forces vs. number of samples, c) Force on the X-axis with its envelope vs the angular position, d) Force on the Y-axis and its envelope vs. angular position, e) Resulting force calculated as vectors sum of X- and Y-axis components vs. angular position, and f) Resulting force is divided in two halves corresponding to half disks and the two halves averaged.*

To summarize, this simple data processing doesn't allowed to obtain the true values of cutting forces, but at least to make a first assessment of the possibility to make comparisons unmodified and thermally modified wood. The same procedure could ba applied to different materials, using different tools etc.

RESULTS AND DISCUSSION

The data obtained applying the above presented method when machining unmodified and thermally modified wood are shown in Figure 3. The continuous line indicates unmodified wood while dashed line indicates thermally modified wood. In blue are shown the cutting forces when machining at 0.3 mm of depth of cut (*DOC*), in red when machining with 0.7 mm DOC, and in orange when machining with 1.1 mm DOC.

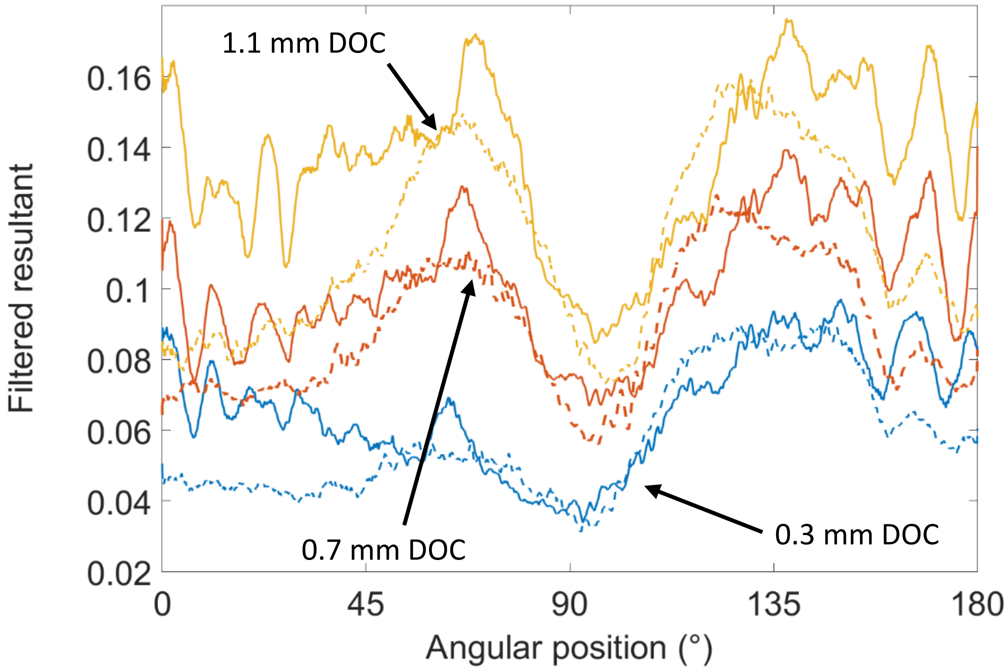

Figure 3: Filtered cutting forces normalized by the engaged blade length when machining unmodified (continuous line) and thermally modified (dashed line) wood. In the lower part with a depth of cut (DOC) of 0.3 mm, in the upper part of 1.1 mm and in the middle of 0.7 mm.

It can observe, as expected, a clear trend of increased cutting forces with increasing both for unmodified and thermally modified wood. A clear difference in cutting forces related to wood anisotropy can also be observed when machining at different angular positions. The minimum force is reached when machining along the grain (angular position 90°) while the maximum is got when machining against the grain (angular position between 14 and 160°). These results are coherent with previous investigations conducted on maple (Costes *et al.* 2004) and Douglas fir (Goli *et al.* 2010). Repeatable trends between unmodified and thermally modified wood can also be observed for the different *DOC*s. In particular, it can be concluded that the forces acting when machining, either modified or unmodified wood, along the grain are very similar (*i.e* around Φ=90 °C). On the other hand, while machining with or against the grain, thermally modified wood shows much lower cutting forces compared to unmodified wood.

CONCLUSIONS

The proposed experimental set up has shown to work fine even if at present the data analysis should be improved. The use of filtering at the beginning of the data treatment allows to compare cutting forces while machining modified and unmodified wood and to investigate the impact of grain orientation. The method is proved to be relevant to study the impact of thermal modification of wood on cutting forces. However, the analysis procedure presented in this work does not allow to conclude quantitatively on the real cutting forces applied on the tool since a strong filtering tends to reduce the measured signal's amplitude. To do so, more suitable data analysis technics are currently under development.

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REFERENCES

Budakçı M., Cemil İlçe A., Gürleyen T. and Utar M. (2013). Determination of the surface roughness of heat-treated wood materials planed by the cutters of a horizontal milling machine. *BioResources* **8**, 3189-3199.

Costes J.-P., Ko P.L., Ji T., Decès-Petit C. and Altintas Y. (2004). Orthogonal cutting mechanics of maple: modeling a solid wood-cutting process. *Journal of Wood Science,* **50**, 28-34. doi: 10.1007/s10086-003-0527-9.

de Moura L.F., Brito J.O., Nolasco A.M. and Uliana L.R. (2011). Effect of thermal rectification on machinability of Eucalyptus grandis and Pinus caribaea var. hondurensis woods. *European Journal of Wood and Wood Products,* **69**, 641-648. doi: 10.1007/s00107-010-0507-x.

de Moura Palermo G.P., de Figueiredo Latorraca J.V., de Moura L.F., Nolasco A., Monteiro de Carvalho M. and Rosilei Aparecida G. (2014). Surface roughness of heat treated Eucalyptus grandis wood. *Maderas. Ciencia y tecnología,* **16**. doi: 10.4067/S0718-221X2014005000001.

Finnish ThermoWood Association (2003). ThermoWood Handbook.

Goli G, Fioravanti M, Marchal R, Uzielli L. and Busoni S. (2010). Up-milling and down-milling wood with different grain orientations-the cutting forces behaviour. *European Journal of Wood and Wood Products,* **68**, 385-395.

Goli G, Sandak J (2016). Proposal of a new method for the rapid assessment of wood machinability and cutting tool performance in peripheral milling. *European Journal of Wood and Wood Products*, **74**, 867-874. doi: 10.1007/s00107-016-1053-y.

Palermo Pires De Moura G., De Figueiredo Latorraca J.V., De Carvalho Monteiro A. and Garcia R.A. (2015). Surface evaluation of the heat treated wood of Eucalyptus grandis Hill ex Maiden. Ciência Florestal, **25**, 145-152.

Sandak J., Goli G., Cetera P., Sandak A., Cavalli A. and Todaro L. (2017). Machinability of Minor Wooden Species before and after Modification with Thermo-Vacuum Technology. *Materials (Basel)*, **10**. doi: 10.3390/ma10020121.

Tu D., Liao L., Yun H., Qiaofang Z., Xinlei C. and Jun H. (2014). Effects of heat treatment on the machining properties of Eucalyptus urophylla×E. camaldulensis. *BioResources,* **9**, 2847-2855.

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